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The Transplant Index (TI): a novel method to predict adult liver transplant waitlist outcomes

Kueht, Michael ; Bakhtiyar, Syed Shahyan ; Wu, Jessie ; Liu, Hao ; Chan, Warren H ; Petrowsky, Henrik ; Riaz, Irbaz B ; Cotton, Ronald ; Galvan, Nhu Thao ; O'Mahony, Christine ; Goss, John ; Rana, Abbas

Abstract: BACKGROUND: The field of transplantation is shifting outcome priorities from 1-year survival to more comprehensive metrics including transplant rate and waitlist mortality. Identifying disenfranchised candidates (high waitlist death risk, low transplantation chance) can be a focus to improve outcomes. METHODS: Given waitlist outcomes, (continued waiting, death, and transplantation), we aimed to identify factors predicting the likelihood candidates would undergo transplant or death by performing multivariate competing risk analyses of 121 198 candidates in the United Network for Organ Sharing database. We incorporated these probabilities (likelihood of transplantation and waitlist death) into the transplant index (TI) to identify disenfranchised candidates (high likelihood of death, low likelihood of transplantation). RESULTS: Half of the patients had low incidences of death and transplantation within 90 days (TI-inactive). The remaining were stratified into 10 groups within a predictive index, the TI. Low-TI groups (TI-10, 20, 30) had 90-day transplant rates of 50.8%, 41.6%, and 39.8% respectively, and their respective 90-day death rates were 22.8%, 15.1%, and 10.9%. High-TI groups (TI 80, 90, >90) had 90-day transplantation rates of 53.7%, 64.3%, and 73.9% respectively, and 90-day death rates of 5.9%, 6.5%, and 6.7% respectively. As TI increased, the likelihood of transplantation increased and that of death decreased. Low-TI groups represent the disenfranchised candidates. CONCLUSIONS: The TI identifies disenfranchised candidates on the adult liver transplant waitlist. This is the subgroup that would benefit the most from efforts to increase access to transplantation.

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The Transplant Index (TI): A Novel Method To Predict Adult Liver Transplant Waitlist Outcomes

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AUTHORSHIP STATEMENT

Abbas Rana participated in conceptualization of the study, data analysis and drafting the initial manuscript. Jessie Wu and Hao Liu participated in the conceptualization of the study and the data analysis. Michael Kueht, Syed Shahyan Bakhtiyar, John Goss, Warren H. Chan, Ronald Cotton, Nhu Thao Galvan, Christine O'Mahony, Henrik Petrowsky, Irbaz B. Riaz, Abbas Rana, Jessie Wu, and Hao Liu reviewed, revised, and approved the final manuscript.

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ABBREVIATIONS

BMI, body mass index; CI, confidence interval; DCD, donation after cardiac death; DRI, Donor Risk Index; DSA, donor specific area; HCC, hepatocellular carcinoma; HR, hazard ratio; ICU, intensive care unit; MELD score, Model for End-Stage Liver Disease score; POT, Probability of 90-day waitlist Transplant; POD, Probability of 90-day waitlist Death; SBP, spontaneous bacterial peritonitis; TI, Transplant Index; UNOS, United Network for Organ Sharing

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ABSTRACT

Background: The field of transplantation is shifting outcome priorities from 1-year survival to more comprehensive metrics including transplant rate and waitlist mortality. Identifying disenfranchised candidates (high waitlist death risk, low transplantation chance) can be a focus to improve outcomes.

Methods: Given waitlist outcomes, (continued waiting, death, and transplantation), we aimed to identify factors predicting the likelihood candidates would undergo transplant or death by performing multivariate competing risk analyses of 121 198 candidates in the United Network for Organ Sharing database. We incorporated these probabilities (likelihood of transplantation and waitlist death) into the transplant index (TI) to identify disenfranchised candidates (high likelihood of death, low likelihood of transplantation).

Results: Half of the patients had low incidences of death and transplantation within 90 days (TI-inactive). The remaining were stratified into 10 groups within a predictive index, the TI. Low-TI groups (TI-10, 20, 30) had 90-day transplant rates of 50.8%, 41.6%, and 39.8% respectively, and their respective 90-day death rates were 22.8%, 15.1%, and 10.9%. High-TI groups (TI 80, 90, >90) had 90-day transplantation rates of 53.7%, 64.3%, and 73.9% respectively, and 90-day death rates of 5.9%, 6.5%, and 6.7% respectively. As TI increased, the likelihood of transplantation increased and that of death decreased. Low-TI groups represent the disenfranchised candidates.

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Conclusions: The TI identifies disenfranchised candidates on the adult liver transplant waitlist. This is the subgroup that would benefit the most from efforts to increase access to transplantation.

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1. INTRODUCTION The most critical factor limiting access to liver transplantation is the limited supply of deceased donor allografts. Increasing organ utilization of the existing donor supply becomes the key to increasing rates of transplantation.[1, 2] Identifying disenfranchised (high risk of death on the waitlist, low chance of transplantation) candidates and increasing organ utilization for these patients, will have the greatest impact on waitlist outcomes. While there are several strategies to increase organ utilization, the most prominent is the use of marginal or "extended-criteria donors", which has been reported to reduce pretransplant mortality by up to 50%.[3, 4] "Extended-criteria donor" is a broad and imprecise term that incorporates many different types of allografts, including older and steatotic allografts, CDC high risk allografts, Hepatitis B positive allografts, Hepatitis C positive allografts, donors with CNS malignancies, and donors with hypercoagulable states, among others.[5, 6] A second prominent strategy to increase access to transplantation is the use of living donors.[7] Finally, more conservative recipient exclusion criterion and more aggressive acceptance of donor offers in a general sense may serve to increase organ utilization and can be done while preserving posttransplant outcomes.[8, 9] A model to help physicians and candidates understand the likelihood of death vs. transplantation could assist identifying disenfranchised candidates (high risk of death on the waitlist, low chance of transplantation) that would benefit most from strategies to increase access to transplantation. We sought to identify factors predicting the likelihood of waitlist activity (transplantation or death) and then to use competing risk and cox regression analyses to stratify candidates based on the likelihood of 90-day liver transplantation vs. death.

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2. METHODS

2.1 Study Population. In our retrospective analysis of United Network for Organ Sharing (UNOS) deidentified patient-level data, we reviewed the records of all candidates listed for liver transplantation from March 1, 2002, through September 30, 2016 (n = 166 162). We excluded the following: candidates younger than 18 years (n = 11 407); candidates listed for a combined liver-heart, liver-lung, or liver-intestine transplant (n = 636); candidates with board-approved exception points for hepatocellular carcinoma (HCC) or other reasons (n = 29 806); and candidates who underwent a living donor liver transplant (n = 3115). A separate analysis was conducted solely with candidates with board-approved exception points (n = 29 806). All candidates were followed until death or the date of last known follow-up. We included 121 198 candidates in our final study group. This study was conducted in compliance with local institutional review board requirements. The UNOS data was already deidentified when obtained and any potential identifiers were further codified for analysis.

2.2 Statistical Analysis. Variables with low levels of completion in the UNOS database were excluded from the analyses. Continuous variables were reported as the mean ± standard deviation and compared using the Student t test. Categorical variables were summarized as frequencies and percentages, and compared using the Chi-square test. Time to Transplant was analyzed using the competing risk method with death as a competing risk for transplant.[10] Time to death was analyzed using the Cox proportional regression survival analysis. All variables with p values < 0.05 in the univariate analysis were included in the multivariate analyses. All reported P values were 2-sided.

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2.3 Transplant Index (TI). Separate regression equations for the probability of 90-day waitlist transplantation (POT) and probability of 90-day waitlist death (POD) were generated utilizing the competing risk method (Figure1a). Waitlist activity was calculated by taking the sum of POT and POD (Figure 1b). The 50% of candidates with the lowest levels of waitlist activity, ie, low incidences of both death and transplantation, were identified as TI-inactive. Using the regression equations for POT and POD, the Transplant-Index was calculated as their mathematical difference (Figure 1b). For the remaining 50% of candidates (not TI-inactive), we individually calculated the TI and stratified them into 10 roughly equal groups (TI-10, 20, 30, 40, 50, 60, 70, 80, 90, >90), thus identifying patients with disproportionate likelihoods of transplant vs. death.

2.4 Predictors. Recipient and donor risk factors included in the multivariable analysis are listed in Tables 1 and 2. All available potential predictors were recorded, for each candidate, at the time of listing.

3. RESULTS

3.1 Study Population. After exclusions, our final study group included 121 198 candidates. The mean age of the candidates was 51.9 ± 10.4 years. The average MELD score at transplant was 22.3 ± 11.1. Demographic and clinical characteristics, summarized by TI category, are in Table 3.

3.2 Waitlist Activity. Similar to the ability of the MELD score to predict waitlist mortality, we used 90 days as the cutoff for waitlist activity (death and transplantation). As previously mentioned, waitlist activity was calculated as the mathematical sum of POT and POD.

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Candidates with waitlist activity ≤ 0.299 (lower 50% of candidates) were considered TI-inactive (n=61 274 patients), and had extremely low rates of both transplantation and death (6.3 and 2.5%, respectively). Candidates with waitlist activity >0.299 had their TI calculated. Rates of 90-day death and transplantation by TI category are listed in Table 4.

3.3 Transplant Index. The components of our Transplant Index are highlighted in Figure 1. The TI includes the following factors: age, MELD, etiology of liver disease (hepatitis C, alcohol, autoimmune, NASH), need for preoperative life support (vasopressors and/or mechanical ventilation or other circulatory support), transjugular intrahepatic portosystemic shunt (TIPS), retransplant, UNOS region of listing, diabetes mellitus, ABO blood type, hemodialysis, and spontaneous bacterial peritonitis. The probability of transplantation was higher than that of death across all groups. We considered candidates in TI-10, 20 to have disproportionately higher death rates compared to higher TI groups (Figure 2). Similarly, candidates in TI- 10, 20 and TI-80, 90 groups had higher MELD scores than the rest of the candidates, with the average MELD score for the Low-TI groups (TI-10, 20) being 31.1, while that of the High-TI groups was 29 (Figure 3). When analyzing the exception point cohort, 90-day mortality was inordinately low (1.4%) and so competing risk modeling did not result in a reliable predictive index for this subject population.

3.4 Model Discrimination. Our regression equation to predict 90-day transplantation had a C statistic of 0.82. Our regression equation to predict 90-day mortality had a C statistic of 0.77. For reference, the MELD score has previously been validated to predict 90-day waitlist mortality with a C statistic of 0.73.[11]

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3.5 Waitlist and Posttransplant survival. Low-TI candidates that underwent transplantation achieved slightly lower 1-yr survival versus their high-TI counterparts (82% vs 88%, p<0.01) (Figure 4a). Waitlist 1-yr survival was exceptionally low for low-TI candidates (39%). The relative survival benefit was a 49% increase in 1-yr survival if a low-TI candidate was able to be transplanted (Figure 4b).

4. DISCUSSION As demonstrated by this study, there is significant heterogeneity regarding the relative likelihoods of transplantation and death among transplant candidates on the waitlist outside of that predicted by the MELD score. Applying the TI, we identified a significant portion of waitlisted patients with disproportionate risks of 90-day mortality relative to the likelihood of transplantation. It is these patients whom we believe are disenfranchised with regard to access to transplantation.

The TI identifies patients that would receive the most benefit from efforts to increase access to transplantation. Those low-Ti candidates that underwent transplantation had a substantial survival benefit and fared very poorly on the waitlist. Although it identifies disenfranchised patients (highest likelihood of death and lowest likelihood of transplantation), it does not identify which patients are likely to have the best outcomes after transplantation. Identifying these candidates often requires nuanced clinical judgement that is not easily captured by a mathematical index. For example, the use of extended-criteria deceased donors has been shown to be independently associated with inferior outcomes and increased costs.[12] Older donors have been associated with decreased patient and graft survival rates.[13] Prolonged cold ischemia time has been associated with increased hospital stays, biliary strictures, and decreased graft survival rates.[14-16] Steatotic allografts have been linked to increased rates of primary nonfunction, as well

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as to decreased graft and patient survival rates.[16-18] Several studies have linked DCD (donation after cardiac death) donors with increased morbidity rates associated with biliary strictures and with decreased graft and patient survival rates.[19, 20] The TI does not instruct clinicians which candidates are likely to do well with extended criteria donors. However, it does instruct clinicians as to which group of candidates would derive the most benefit in access to transplantation from extended-criteria donors.

Additionally, many of the low-TI candidates have characteristics unfavorable for transplantation (older age, life support, comorbid diagnoses) and there may be a portion of these candidates that are truly unfit for transplantation. However, although low- and high-TI candidates had markedly disparate rates of transplantation, we found that they both had acceptable posttransplant survival. These data show that although some of the low-TI candidates may not be eligible for transplantation, eg, too sick, there are some that can achieve acceptable survival and so should be identified and pursued.

Identifying these disenfranchised individuals, perhaps through a center watch-list of low-TI candidates, could be a clinical role for the TI in waitlist management and organ allocation. The candidates on such a watch-list may be given priority consideration of an extended-criteria donor organ offer. Center-level decision making undoubtedly plays a large role in the disparate rates of transplantation across the TI groups, as evidenced by the significance of listing region in the multivariate analysis. Given that both low- and high-TI candidates have relatively high MELD scores, the current MELD-based allocation policy would favor transplantation of them both in the absence of confounding factors. Although all relevant clinical variables are not captured in the OPTN data, the many factors in our analysis reflect some of the decision making involved in

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deciding which high-risk candidates to transplant. Indeed, our posttransplant survival analysis shows that low-TI candidates that do get transplanted have greater than 80% 1-year posttransplant survival. Given that the calculated 1-year waitlist mortality for low-TI candidates is more than 50%, we believe identifying which of the low-TI candidates are truly transplantable is an important job for the clinician and these data can help guide that process.

The use of competing risk analyses allowed the generation of accurate regression equations with a distinct benefit over traditional Kaplan-Meier survival modeling. Considering all the potential waitlist outcomes is necessary in real-life waitlist management when trying to identify disenfranchised candidates (high likelihood of death, low likelihood of transplantation). Indeed, we discovered that the 50% of the waitlist with the lowest levels of 90-day activity (TI inactive, n=61 274 patients) had extremely low rates of both transplantation and death (6.3 and 2.5%, respectively). Candidates in the TI-inactive group had significantly lower MELD scores, higher serum albumin, and higher rates of HCV infection than the other TI categories. The disenfranchised candidates in the TI 10, 20 groups (high likelihood of death, low likelihood of transplantation) were older with high incidences of DM, HD, life support, and Blood type O. Alternatively, candidates in the TI>90 group (high likelihood of transplantation, low likelihood of death), were younger with lower incidences of HCV infection, DM, and HD.

Using competing risk analysis, the index can accurately identify disenfranchised candidates (high likelihood of death, low likelihood of transplantation). These candidates would benefit the most from efforts to increase access to transplantation and have the greatest impact on waitlist outcomes. In conclusion, the TI is a new mathematical index incorporating the important outcomes on the waiting list: inactivity, death, and transplantation that can be used to identify

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candidates on the waitlist that have a high risk of dying and a low probability of undergoing transplantation. These disenfranchised candidates are the ones that would benefit the most from an increased access to transplantation and after identifying low-TI candidates, deciding which are truly transplantable will become an important task.

5. LIMITATIONS Since the passage of the National Organ Transplant Act of 1984, data entry has been mandatory for all U.S. transplant centers. Nevertheless, all patient registries often suffer from variability in data entry. Certain granular aspects of clinical variable cannot be gleaned from these data, including etiology of renal disease requiring hemodialysis.

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LEGENDS

Figure 1a. Regression equations for calculating a candidate's probability of liver transplantation (POT) and death (POD) within 90 days becoming active on the waitlist.

Figure 1b. Equations used to calculate the Waitlist Activity and the Transplant Index (TI)

MELD, Model for End Stage Liver Disease; BMI, Body Mass Index; diag etoh, diagnosis alcoholic liver disease; diag nash, nonalcoholic steatohepatitis; diag auto, diagnosis autoimmune hepatitis; diag hepc, diagnosis hepatitis C; lifesup, life support; dm, diabetes mellitus; tips, transjugular intrahepatic portosystemic shunt; retx, retransplant; sbp, spontaneous bacterial peritonitis; abo, ABO blood group; hd, hemodialysis

Figure 2. 90-Day Transplant Rates and 90-Day Death Rates among various Transplant Index (TI) categories

Figure 3. MELD Scores of various Transplant Index (TI) Categories

Figure 4. (a) Survival after a Liver Transplant (b) Survival Benefit in Low TI Candidates

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Figure 1

a.

POT =

$$1 - [-0.06884813*(0.07789*X_{\text{initial MELD score}} - 0.00323*X_{\text{age}} + 0.0029*X_{\text{BMI}} - 0.03139*X_{\text{diag etoh = Yes}} - 0.11027*X_{\text{diag auto = Yes}} - 0.03094*X_{\text{diag hepc = Yes}} - 0.36045*X_{\text{lifesup= Yes}} - 0.02663*X_{\text{dm= Yes}} - 0.04604*X_{\text{tips = Yes}} + 0.05555*X_{\text{retx= Yes}} - 0.36697*X_{\text{region=1}} - 0.05274*X_{\text{region=2}} + 0.72046*X_{\text{region=3}} - 0.28353*X_{\text{region=5}} + 0.15117*X_{\text{region=6}} - 0.37769*X_{\text{region=9}} + 0.50982*X_{\text{region=10}} + 0.41451*X_{\text{region=11}} + 0.16968*X_{\text{sbp=Yes}} + 0.74550*X_{\text{abo=AB}} + 0.22415*X_{\text{abo=B}} - 0.04237*X_{\text{abo=O}} - 0.24775*X_{\text{hd= Yes}})]$$

POD =

$$1 - [-0.002785479*(0.0966224*X_{\text{initial MELD score}} + 0.0236356*X_{\text{age}} - 0.0760382*X_{\text{diag etoh = Yes}} - 0.1348595*X_{\text{diag nash = Yes}} + 0.1004834*X_{\text{diag hepc = Yes}} + 0.9297618*X_{\text{lifesup= Yes}} + 0.0924785*X_{\text{dm= Yes}} - 0.1385824*X_{\text{tip = Yes}} + 0.0276309*X_{\text{retx= Yes}} + 0.1628267*X_{\text{region=1}} + 0.1592703*X_{\text{region=2}} + 0.0407678*X_{\text{region=3}} + 0.0238289*X_{\text{region=5}} - 0.2426165*X_{\text{region=6}} + 0.3566405*X_{\text{region=9}} + 0.1604965*X_{\text{region=10}} + 0.2465154*X_{\text{region=11}} + 0.1777921*X_{\text{sbp=Yes}} - 0.1672138*X_{\text{abo=AB}} - 0.0989104*X_{\text{abo=B}} + 0.0002113*X_{\text{abo=O}} + 0.3852846*X_{\text{hd= Yes}})]$$

b.

Waitlist Activity = POT + POD

Transplant Index (TI) = POT – POD

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Figure 2

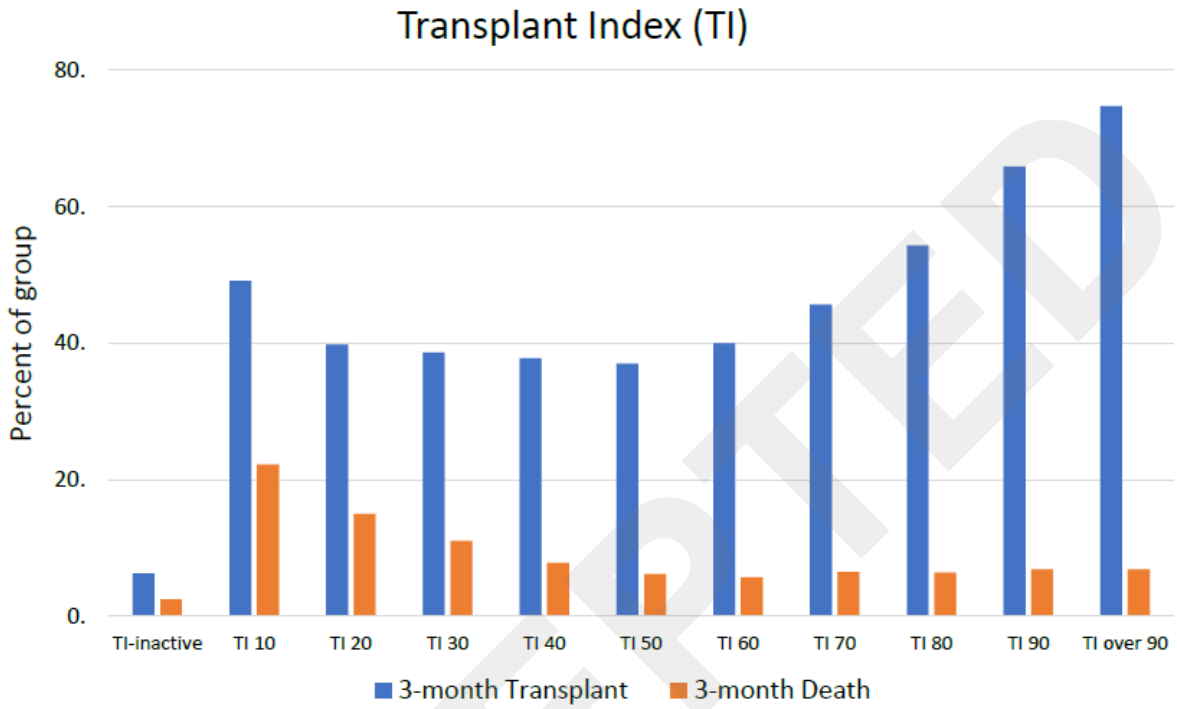

Figure 2. 90-Day Transplant Rates and 90-Day Death Rates among various Transplant Index (TI) categories

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Figure 3

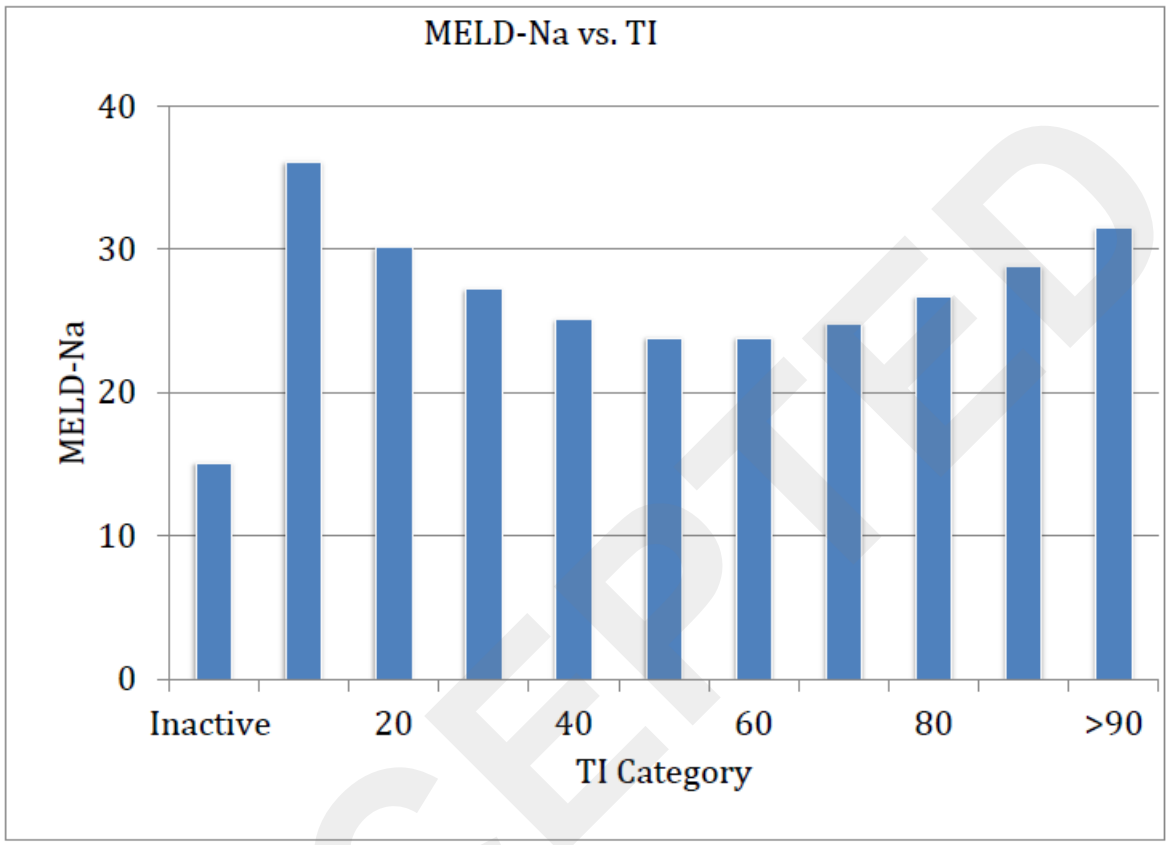

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Figure 4

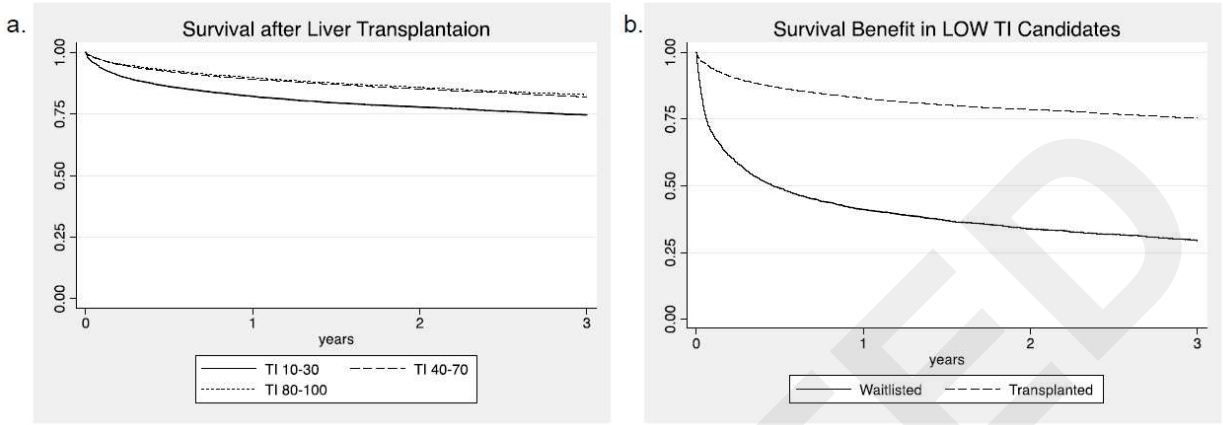

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Table 1. Potential predictors for 90-day waitlist mortality, multivariate analysis

C index= 82.3 %				
	HR	**95% CI**		**P**
Initial MELD lab Score	1.081	1.079	1.083	<0.0001
Initial age	0.997	0.996	0.998	<0.0001
BMI	1.003	1.001	1.005	0.0029
Diag EtOH				
No	1.000			
Yes	0.969	0.944	0.995	0.021
Diag autoimmune				
No	1.000			
Yes	0.896	0.841	0.954	0.0006
Diag HCV				
No	1.000			
Yes	0.970	0.945	0.995	0.019
Life Support				
No	1.000			
Yes	0.697	0.650	0.748	<0.0001
DM				
No	1.000			
Yes	0.974	0.949	0.999	0.038
TIPS				
No	1.000			
Yes	0.955	0.920	0.991	0.015

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Retransplant				
No	1.000			
Yes	1.057	1.007	1.110	0.025
Region				
4-7-8	1.000			
1	0.693	0.653	0.735	<0.0001
2	0.949	0.914	0.985	0.006
3	2.055	1.986	2.128	<0.0001
5	0.753	0.728	0.779	<0.0001
6	1.163	1.087	1.244	<0.0001
9	0.685	0.651	0.721	<0.0001
10	1.665	1.598	1.734	<0.0001
11	1.514	1.454	1.576	<0.0001
SBP				
No	1.000			
Yes	1.185	1.136	1.236	<0.0001
ABO blood type				
A	1.000			
AB	2.107	1.998	2.223	<0.0001
B	1.251	1.210	1.294	<0.0001
O	0.959	0.936	0.982	0.0005
HD				
No	1.000			
Yes	0.781	0.752	0.810	<0.0001

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Table 2. Potential predictors for 90-day waitlist transplant, multivariate analysis

C index= 77.3%				
	HR	**95% CI**		**P**
Initial MELD lab Score	1.101	1.099	1.104	<0.0001
Initial age	1.024	1.022	1.026	<0.0001
Diag EtOH				
No	1.000			
Yes	0.927	0.892	0.963	0.0001
Diag NASH				
No	1.000			
Yes	0.874	0.823	0.927	<0.0001
Diag HCV				
No	1.000			
Yes	1.106	1.067	1.146	<0.0001
Life support				
No	1.000			
Yes	2.534	2.371	2.708	<0.0001
DM				
No	1.000			
Yes	1.097	1.061	1.134	<0.0001
TIPS				
No	1.000			
Yes	0.871	0.825	0.919	<0.0001

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Retransplant				
No	1.000			
Yes	1.028	0.968	1.092	0.371
Region				
4-7-8	1.000			
1	1.177	1.099	1.260	<0.0001
2	1.173	1.119	1.229	<0.0001
3	1.042	0.981	1.106	0.181
5	1.024	0.982	1.068	0.270
6	0.785	0.702	0.877	<0.0001
9	1.429	1.357	1.504	<0.0001
10	1.174	1.098	1.256	<0.0001
11	1.280	1.205	1.359	<0.0001
SBP				
No	1.000			
Yes	1.195	1.128	1.265	<0.0001
ABO blood type				
A	1.000			
AB	0.846	0.765	0.935	0.001
B	0.906	0.862	0.952	0.0001
O	1.000	0.970	1.032	0.9893
HD				
No	1.000			
Yes	1.470	1.413	1.530	<0.0001

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Table 3. Demographic and clinical characteristics of 121,198 waitlisted candidates

	Transplant Index (TI) Category										
	Inactive	10	20	30	40	50	60	70	80	90	>90
n (121,198)	61,274	5,992	5,993	5,992	5,993	5,992	5,993	5,992	5,993	5,992	5,992
Age (yr)	53.9 ±9.8	55* ±11.1	55.6* ±10.3	55.6* ±9.7	54.4* ±9.5	53.2* ±10.1	52.3* ±10.3	51.5* ±10.9	50.3* ±11.1	49.1* ±11.8	45.6* ±12.7
MELD-Na	15.1 ±10	36.1* ±8	30.1* ±7.6	27.2* ±6.8	25.1* ±7.2	23.8* ±7.7	23.8* ±7.7	24.8* ±7.7	26.7* ±7.5	28.8* ±7.1	31.5* ±6.3
DM (%)	25.7	29.4*	32*	27.9*	25.5	25.5	24.6	23.4*	20.7*	18.3*	15.3*
HCV (%)	30.7	21.6*	27.1*	27.6*	26.4*	25.5*	22.9*	22.1*	20.4*	19.1*	15*
ABO - O (%)	49.2	52.8*	50.8*	49.9	47.3*	45*	42.1*	43.1*	40*	39*	31.9*
ABO – A (%)	38.4	37.4	38.7	38.9	39.6	37.6	38.3	35.8*	35.6*	33*	27.1*
ABO – B (%)	10.7	8.9*	9.4*	10.2	11.4	13.7*	14.3*	14.7*	16.8*	18*	20.7*
ABO – AB (%)	1.8	1*	1.2*	1*	1.7	3.7*	5.3*	6.4*	7.6*	10*	20.3*
Restransplant (%)	2	9.2*	5.5*	4.6*	3.7*	4.1*	4.3*	5*	5.8*	7.7*	9.8*
SBP (%)	3.5	11.4*	10.6*	9.9*	9.1*	8.3*	7.9*	9.1*	10*	10.1*	10.3*
HD (%)	6.8	71.9*	55.8*	27*	14.6*	10.6*	9.6*	9.3*	8.6*	7.7*	4.7*

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Life Support (%)	0.9	66.2*	14.6*	5.6*	2.7*	2.1*	1.7*	1.4*	1.4*	1.5*	0.7*
Albumin (g/dL)	3.14 ±0.6	3.02* ±0.8	2.92* ±0.8	2.84* ±0.7	2.84* ±0.7	2.86* ±0.7	2.89* ±0.7	2.85* ±0.7	2.83* ±0.7	2.83* ±0.7	2.84* ±0.8

* $p<0.05$ compared to TI inactive

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Table 4. 90-Day Transplant Rate and 90-Day Death Rate of various Transplant Index (TI) Categories

TI Category	TI Values	Transplant Rate (%)	Death Rate (%)
TI-inactive	*	6.3	2.5
TI 10	≤ 0.031	50.8	22.8
TI 20	> 0.031, ≤ 0.131	41.6	15.1
TI 30	> 0.131, ≤ 0.184	39.8	10.9
TI 40	> 0.184, ≤0.220	37.7	8.6
TI 50	> 0.220, ≤ 0.250	37.3	6
TI 60	> 0.250, ≤ 0.283	39	6
TI 70	> 0.282, ≤ 0.322	44.6	6.2
TI 80	> 0.322, ≤ 0.375	53.7	5.9
TI 90	> 0.375, ≤ 0.462	64.3	6.5
TI over 90	> 0.462	73.9	6.7

* TI-inactive category has waitlist activity of < 0.299.

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